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Blocking Performance Comparison for Guard and Limited Fractional Guarded Channel Policy in Wireless Cellular Networks

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Abstract: In Cellular networks, blocking is given by when base station has no free channel to allocate to a mobile user. There are two kinds of blocking, the first is called new call blocking which refers to blocking of new calls, the second is called handoff blocking which refers to blocking of ongoing calls due to the mobility of the user. In Cellular Networks, specifically to manage channels in order to minimize the effects of blocking during peak traffic. The focus of this work is a comparative analysis of blocking performance between two channel allocation policies, namely the Guard Channel Policy (GCP) and the Limited Fractional Guard Channel Policy (LFGCP). Analysis of this work includes blocking probability for new and handoff calls by means of simulations while increasing the steady traffic. Further, we are going to analyze and test of both these polices in our project. And at the end we are going to conclude that which one is best policy under Channel Reservation Technique.

1.INTRODUCTION

Cellular networks are always based on the concept of dividing the service area into smaller regions known as cells, each served by a base station which takes care of the communication between mobile devices and the core network. Cellular networks remain the backbone of today's modern wireless communications that enable mobile users to communicate seamlessly across large geographical areas. The architecture of cellular networks supports wide-ranging applications from voice calls to high-speed data services and is designed in such a way that reliable communication can be achieved when users switch between different cells, a process known as handoff or handover.

Key Elements of a Cellular Network:

Base Stations (BS): Each cell in the network contains a base station that manages communication with the mobiles. The base station will allocate free radio channels to be used for the calls and data sessions.

Mobile Switching Centers (MSC) It is a central hub that connects multiple base stations and thus acts as an interface between the cellular network and other telecommunication networks like the PSTN.

Mobile devices. Devices operated by users, such as smart phones or tablets, that connect to the network via the base stations.

Handoff Process: When a mobile device switches from one cell to another, the next cell base station assumes the active call or data session without dropping, thereby completing the seamless handoff for the user.

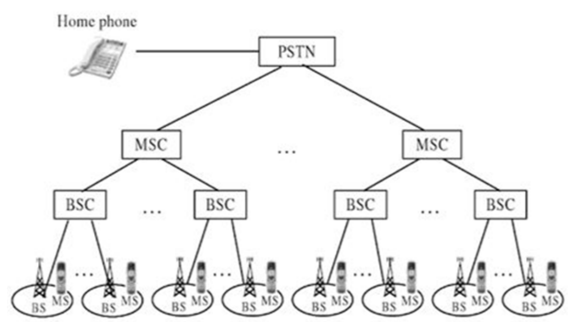


Fig: cellular system infrastructure

Call Admission Control Policies:

Several Call Admission Control policies are designed to try and mitigate the problem of call blocking by prioritizing traffic and efficiently allocation resources. Some common policies include

Guard Channel Policy(GCP): Carries a fixed number of channels for hand-off calls to avoid decrease blocking probability, causing potential resource under utilization during low traffic.

Limited Fractional Guard Channel Policy(LFGCP): This is a dynamic system that dynamically can allocate a fraction of the available channels for handoff calls by real-time traffic in the channel usage to optimize levels acceptable enough of call blocking.

2.LITERATURE SURVEY

Performance analysis of fractional guard channel policies in mobile cellular network was published by juse luis Vazquez-Avila,Felipe A.cuez-perez and luerro ortigoza Guerrero and this paper helps in analysing the fractional guard channel policies by using recursive formulas for the new call blocking and handoff failure probabilities for fractional guard policies in cellular network are derived.

On optimal call admission control in cellular network was published by Ramachandran Ramjee a, Don Towsley a and Ramesh Nagarajan b. The paper focuses on minimizing new and handoff call blocking probabilities in cellular networks. The paper develops simple and efficient algorithms for determining optimal parameters for these policies.

Performance Analysis of the Guard Channel Scheme with Self-Similar Call Arrivals in Wireless Mobile Networks by was published by Geyong Min and Xiaolong Jin. The study suggests that optimizing the number of guard channels can significantly improve the balance between new and handover call handling, enhancing overall network efficiency.

3.METHODOLOGY

3.1 Guard Channel Policy

The GC policy operates by reserving a predetermined number of channels for handoff calls, ensuring that ongoing calls are less likely to be dropped during cell transitions. This approach maintains a balance between accepting new calls and preserving resources for handoff scenarios.

Algorithmic Process: Guard Channel Policy

The GC policy can be implemented through the following step-by-step process:

Step 1: Initialization

Define the total number of channels, denoted as “C,” available in the cell.

Set a threshold “T” such that “C - T” channels are reserved exclusively for handoff calls.

Step 2: Call Arrival

When a call (new or handoff) arrives, check the current channel occupancy.

Step 3: New Call Handling

If the number of occupied channels is less than “T,” accept the new call.

If the number of occupied channels is greater than or equal to “T,” reject the new call.

Step 4: Handoff Call Handling

If a handoff call arrives and there are available channels, accept the handoff call.

If no channels are available, reject the handoff call.

Step 5: Channel Release

When a call (new or handoff) completes, release the occupied channel.

Formulas for calculating handoff call blocking probability and new call blocking probability in Guard Channel Policy:

Steady-State Probability:

$$P_j = \begin{cases} \dfrac{\rho^j}{j!} P_0, & 0 \le j \le T, \\ \dfrac{\rho^j \alpha^j - T}{j!} P_0, & T+1 < j \le C, \end{cases}$$

Normalizing constant(P_0):

$$P_0 = \frac{1}{\sum_{j=0}^{T} \frac{\rho^j}{j!} + \sum_{j=T+1}^{C} \frac{\rho^j \alpha^{j-T}}{j!}}$$

Blocking Probabilities:

Handoff Blocking Probability:

$$B_h(C,\beta) = P_C$$

New Call Blocking Probability:

$$B_n(C,\beta) = \sum_{j=0}^{C} (1-\beta_{j+1}) P_j,\ \beta_{C+1} = 0$$

Note:

$\beta_i = 1,\ 1 \le i \le T$

$\beta_i = 0,\ T+1 \le i \le C$

3.2 The Limited Fractional Guard Channel Policy

The LFGC policy builds on the GC policy by allowing some flexibility in channel allocation. Instead of rigidly reserving channels for handoff calls, the LFGC policy permits a fractional and dynamic reservation mechanism, where channels are probabilistically assigned to handoff or new calls based on current traffic conditions.

Algorithmic Process: Limited Fractional Guard Channel Policy

The LFGC policy can be implemented through the following steps:

- Step 1: Initialization

Define the total number of channels, denoted as "C," available in the cell.

Set a fractional threshold "F" such that a fraction of the channels is probabilistically reserved for handoff calls.

- Step 2: Call Arrival

When a call (new or handoff) arrives, check the current channel occupancy and calculate the probability of channel allocation.

- Step 3: New Call Handling

If the number of occupied channels is less than "C," calculate the probability of acceptance based on "F."

If the probability condition is met, accept the new call; otherwise, reject it.

- Step 4: Handoff Call Handling

If a handoff call arrives and there are available channels, accept the handoff call with a high probability (determined by "F").

If no channels are available, reject the handoff call.

- Step 5: Channel Release

When a call (new or handoff) completes, release the occupied channel.

Formulas for calculating handoff call blocking probability and new call blocking probability in Limited Fractional Guard Channel Policy:

Steady-State Probability:

$$P_j = \frac{\rho^j \prod_{i=1}^{j} \gamma_i}{j!} P_0, 0 \le j \le C$$

Normalizing constant(P_0):

$$P_0 = \frac{1}{\sum_{j=0}^{C}\left(\frac{\rho^j \prod_{i=1}^{j}\gamma_i}{j!}\right)}$$ Where $\gamma_i=\alpha+(1-\alpha)\beta_i$, $1 \le i \le C$

Blocking Probabilities:

Handoff Blocking Probability:

$$B_h(C,\beta) = P_C$$

New Call Blocking Probability:

$$B_n(C,\beta) = \sum_{j=0}^{c} (1-\beta_{j+1})P_j,\ \beta_{C+1} = 0$$

Note:

$\beta_i = 1,\ 1 \le i \le T$

$\beta_i = 0,\ T+1 \le i \le C$

3.3 Simulation Setup:

The simulations are conducted using Python and Google Colab, with different traffic scenarios analyzed:

- Low Traffic: Minimal channel occupancy, leading to fewer blocked calls.
- High Traffic: Higher channel occupancy and increased blocking probabilities.

Key parameters:

- New Call Arrival Rate (λ1)
- Handoff Call Arrival Rate (λ2)
- Total Number of Channels (C)
- Service Rate (MU)
- Threshold Channel (T)

3.4 Traffic Scenarios: Traffic scenarios ranged from low to high, simulating conditions of minimal to maximum channel utilization.

3.5 Performance Metrics: The study evaluates:

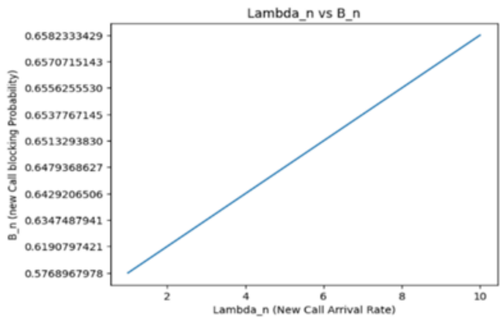
- New Call Blocking Probability (Bn): Likelihood of blocking a new call request.
- Handoff Call Blocking Probability (Bh): Likelihood of dropping a handoff call.
- Overall Channel Utilization: Percentage of channels actively in use.

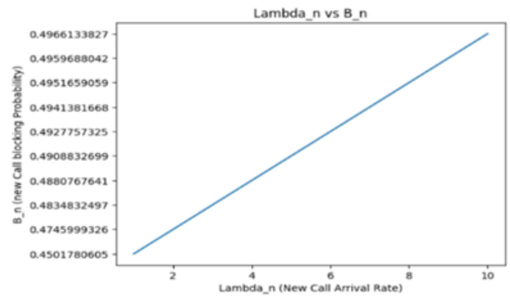
4. RESULTS AND DISCUSSION

The graph is a diagram shows the relation between variable quantities typically two variables, here we are going to visualize and summarize the policies by comparing the guard channel and limited fractional gurad channel policy using graphs. Drawing the graphs between different parameters they are in total twelve graphs are obtained four graphs are of guard channel policy,four graphs are of limited fractional guard channel policy and finally we get resultant four graphs by comparing both the graphs.

Graphs in guard channel policy and limited fractional guard channel policy:

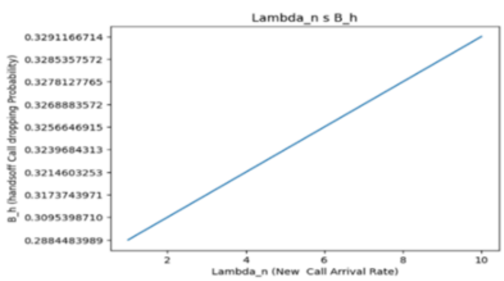
This graph visualizes the relationship between the new call arrival rate (Lambda_n) and the new call blocking probability (B_n) as the graph below is increasing linearly. As the arrival rate increases, the blocking probability also tends to increase.

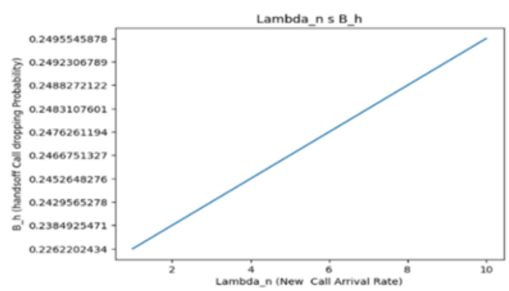




GCP LFGCP

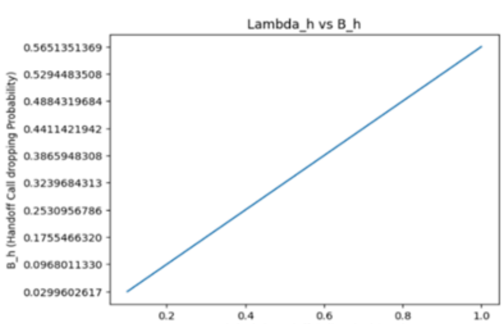
This graph visualizes the relationship between the new call arrival rate (Lambda_n) and the handoff call blocking probability (B_h) as the graph below is increasing linearly. It's likely that as new calls increase, there are fewer resources for handoff calls, potentially increasing the dropping probability.

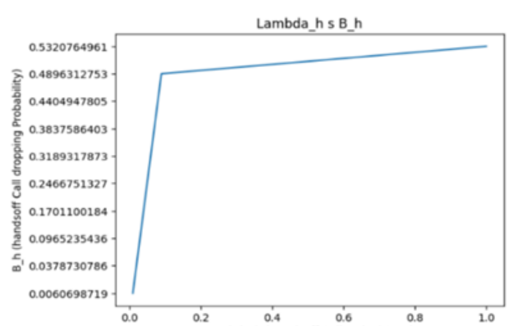




GCP LFGCP

This graph visualizes the relationship between the handoff call arrival rate (Lambda_h) and the handoff call blocking probability (B_h) as the graph below is increasing linearly. . A higher handoff call arrival rate may lead to an increased dropping probability.





GCP LFGCP

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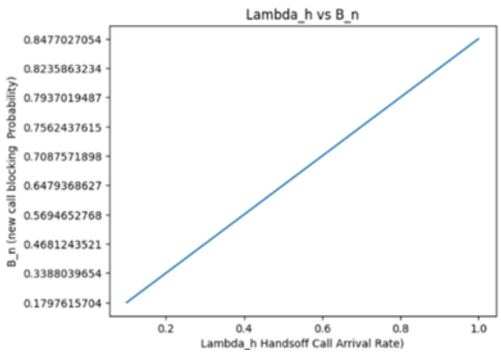
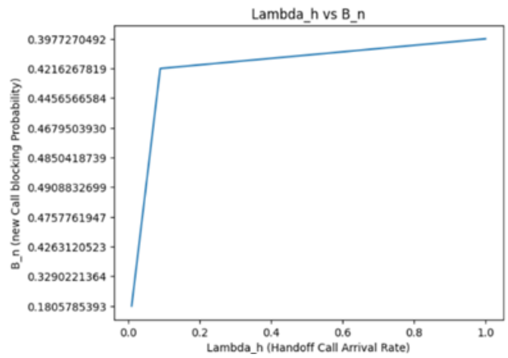
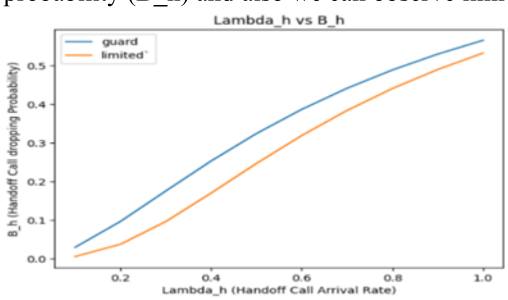


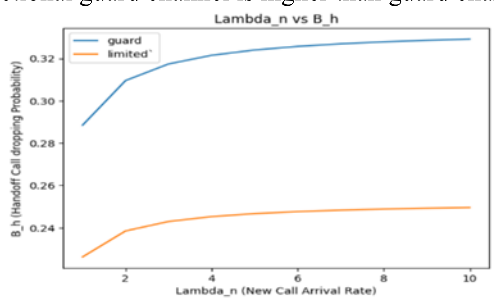
GCP



LFGCP

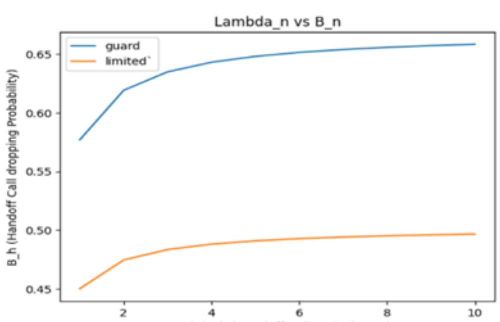
Comparison of graphs between gurad and limited fractional guard channel policy:
The below graph visualizes the relationship between the new call arrival rate (Lambda_n) and the new call blocking probability (B_n) and also we can observe limited fractional guard channel is higher than guard channel policy.

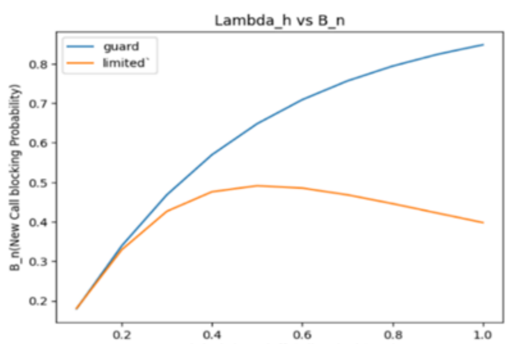




This graph visualizes the relationship between the new call arrival rate (Lambda_n) and the handoff call blocking probability (B_h).

This graph visualize the relationship between the handoff call arrival rate (Lambda_h) and the handoff call blocking probability (B_h) as the graph below is increasing linearly.





This graph visualizes the relationship between the handoff call arrival rate (Lambda_h) and the new call blocking probability (B_n) as the graph below is increasing linearly.

5. CONCLUSION

This study concludes that the Limited Fractional Guard Channel Policy is the superior call admission strategy for wireless cellular networks. By dynamically adjusting channel allocations based on traffic conditions, LFGCP minimizes blocking probabilities and enhances resource utilization. It outperforms the traditional Guard Channel Policy, particularly under high traffic conditions, making it the optimal choice for modern cellular networks.

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